

REMARKS/ARGUMENTS

Claims 1-54 are pending. Claim 1 has been amended to recite that (1) the metallic pigments described therein are produced by milling and (2) that the subject metallic pigments are primed, prior to the application of an enveloping coating, with at least one silicon dioxide barrier layer.

Support for the recitation to the effect that the pigments are produced by milling (thus providing the subject pigments with certain well-known characteristics which would be well understood by one having an ordinary level of skill in this field of art) is provided by the Examples and the Figures contained in the as-filed application. That is, the pigments used in the Examples are obtained by milling. This would be immediately apparent to one having ordinary skill in this art from the product name of the pigments used in the subject Examples. That is, the abbreviation "PCR" designates aluminum pigments (produced by milling) having an SiO_2 coating, whereas the tradename "Dorolan" designates gold bronze pigments (produced by milling) with an SiO_2 coating. The numbers, such as "501" in Example 1 and "212" in Example 4 indicate the particle size of the milled pigments. Furthermore, the tradename "'Standart'" always is used to designate metallic powders. In contrast to the milled pigments used in the Examples, PVD pigments (i.e., which are not milled) are only available as highly diluted suspensions having a solids content of 5 to 10%, since otherwise the PVD pigments would agglomerate.

Figures 1 and 2 filed with the application provide additional evidence that the pigments which are the subject of the applicants' invention are produced by milling. That is, the pigments shown in Figs. 1 and 2 do not have straight edges, i.e., their edges are highly irregular. This thus evidences the fact that the pigments were produced by milling since, in contrast, aluminum pigments formed by the PVD technique would have straight edges. Thus, the lack of such straight edges as noted above evidences that the pigments were formed by milling.

Further to the above, support for the amendment regarding the priming layer is found in original claim 9 as well as on page 11, lines 5-6 of the specification as filed (corresponding to paragraph [0063] of the published U.S. application, No. 2009/0264575 A1).

No new matter is, thus, introduced into the application by the above-described amendments to claim 1. Claims 8, 9 and 47 have, moreover, been canceled from the application

without prejudice or disclaimer due to the amendment to claim 1. Furthermore, the dependency of claim 10 has been changed from claim 8 to claim 1 due to the cancellation of claim 8. Entry of the proposed amendments into the file of the application is respectfully requested. Upon such entry, claims 1-7, 10-46 and 48-54, as amended, will be pending in the application. Reconsideration of the application is respectfully requested.

Amendment to the Title

In the Preliminary Amendment filed with this application on June 23, 2006 the title of the invention was deleted and replaced with the following (see p. 3): “Metallic Pigments Having a Cross-linkable Coating of Binding Agent, Coating Composition, Process for the Preparation of Said Coated Metallic Pigments, and Use of Said Colored Metallic Pigments”.

It has, since, been recognized that “said colored metallic pigments” at the end of the title should have read, “said coated metallic pigments”. Thus the title has been amended in this submission to make the indicated correction. The Office is respectfully requested to adjust its records regarding this application accordingly.

Claim Rejections Under 35 U.S.C. §102

In ¶2 at p. 2 of the Action, claims 1-7, 11, 14, 17, 22, 26, 27, 28-34, 35-38, 40, 41, 43, 44, 52 and 53 are rejected under 35 U.S.C. 102(b) as being allegedly anticipated by U.S. PATENT 3,932,347 to Camelon et al. (“Camelon”). The rejection is respectfully traversed.

In response to the rejection claim 1, i.e., the only independent claim, has been amended as indicated above to recite that the claimed metallic pigments are primed, prior to the application of the enveloping coating, with at least one silicon dioxide barrier layer, i.e., to provide increased chemical resistance to corrosion (see, e.g., p. 11 at lines 5-8 in the specification as filed).

The cited Camelon reference describes aluminum metal particles used as color producing components in a powder coating composition. In contrast to applicants’ metallic pigments as presently claimed (e.g., in claim 1) the particles described by the reference are individually encapsulated in a thin and continuous coating of a particulate organic film-former prior to mixing

with a particulate organic material which serves as the principle film-former of the powder coating composition. According to, e.g., claim 1 of Camelon, the film former is selected from the group consisting of thermoplastic particulate film formers and thermosettable particulate film formers which are, as indicated above, organic materials. The reference, therefore, does not disclose every one of the claimed features recited in, e.g., claim 1 since it does not teach (as presently recited in claim 1) to prime a metallic pigment, prior to enveloping the coating with a cross-linkable coating, with at least one barrier layer of silicon dioxide. Silicon dioxide, as is well known, is an inorganic, not an organic, coating material.

For the reason(s) above, therefore, the Examiner is respectfully requested to reconsider and withdraw the rejection of claim 1 under §102(b) since the claim is not anticipated by Camelon et al. Furthermore, since the remaining claims rejected for anticipation all depend, directly or indirectly, from claim 1, they each include all of the features recited in the subject independent claim. Thus the rejected dependent claims are all deemed to be distinguishable over the cited reference for the same reasons as claim 1 and the rejection of those claims under §102(b) should be withdrawn as well.

Claim Rejections Under 35 U.S.C. §103

In ¶20 on p. 6 of the Action claims 1-7, 11, 14, 17, 22, 26, 27, 28-34, 35-38, 40, 41, 43, 44, 52 and 53 are rejected under 35 U.S.C. §103 over the Camelon '347 patent. The rejection is respectfully traversed.

As noted above in the discussion concerning the rejection under 35 U.S.C. 102(b) based on the same reference, applicants' sole independent claim (no. 1) has now been amended to recite the existence of a silicon dioxide (i.e., inorganic) barrier layer between the pigment surface and the outer enveloping coating. Camelon, however, teaches to use instead an organic coating layer comprised of a thermoplastic, particulate film-former or a thermosettable particulate film-former (see, e.g., claim 1), i.e., which are all organic materials. According to, e.g., col. 3, lines 2-9 of the reference the organic coating is important in that it allows a substantial percentage of the underlying metal flakes to be oriented parallel to the substrate to which they are applied, even

when the powder coating material is applied to the substrate by conventional electrostatic spray painting.

There is no teaching or suggestion to be found anywhere within the subject reference which would disclose, or which would even suggest to one having an ordinary level of skill in this field, to replace the organic layer taught in Camelon et al. with an inorganic layer, and particularly not with an inorganic layer of silicon dioxide. That is, nowhere in Camelon is there even a suggestion that replacing the organic layer with an inorganic coating, i.e., of SiO₂ could or would perform the same function as the organic coating, i.e., that of allowing a substantial percentage of the underlying metal flakes to be oriented parallel to the substrate. Thus, there is no basis in Camelon for making the indicated substitution and applicants therefore respectfully submit that the subject reference would not in any way suggest applicants' metallic pigment as now claimed.

The Examiner is therefore requested to reconsider and withdraw the rejection under 35 U.S.C. 103 of claim 1 and the claims depending therefrom based on the disclosure contained in the Camelon et al. U.S. '347 patent.

Further, in ¶23 at pp. 6-7 of the Action claims 8-10, 25 and 46-49 are rejected under 35 U.S.C. 103 over the Camelon reference in view of Kaupp et al. US 2002/0168484 A1. According to, e.g., ¶25 of the Office Action, the Kaupp reference is cited due to its disclosure that aluminum flake pigments may be coated with passivation layers that prevent corrosion. As further pointed out in Office Action ¶25, moreover, several embodiments of passivation layer-forming materials are taught in the Kaupp reference, among which are (at least one) metal oxide layer and/or metal hydroxide layer - as described in paragraph [0016] of the subject reference.

However, with reference to the issue of obviousness it is important to point out that the subject reference does not teach or suggest that any metal oxide and/or metal hydroxide may prove useful in forming the passivation layer. Rather, the authors of the reference list a specific group of useful metals from which such metal oxide/metal hydroxide layers can be formed. The subject metals listed in the reference are as follows: B, Al, Sn, Ti, V, Cr, Mo, Zn and Ce. It is to be noted, however, that silicon is not included and, thus, silicon dioxide (SiO₂) is not one of the metal oxide layers disclosed by the reference.

Nor should this material (i.e., SiO₂) be considered as having been suggested by the reference. The authors apparently made a conscious effort to exclude it from the list of metals they felt were useful in their invention. They might have, for example, indicated that the metals recited in paragraph [0016] were listed as examples of materials that would work in the invention. They chose not to do so, however. Instead, they intentionally chose to recite that the passivating layer of their invention in the present context is at least one metal oxide and/or metal oxide layer formed from a specific (i.e., exclusive) group of metals (i.e., and only from the indicated group). This can hardly be said, then, to suggest the use of metals that are not included in the recited group. Applicants must take the position, therefore, that those metals not included in the list provided in paragraph [0016] of Kaupp do not form a part of the invention described in the subject reference and that Kaupp et al's failure to list the specific metal oxide chosen for use by the present applicants takes applicants' claimed barrier layer(s) outside the ambit of the disclosure contained in the subject reference since it can not be construed as even suggesting the inclusion of a SiO₂ barrier layer as presently recited in applicants' claims.

Further to the above, applicants have determined that priming the milled aluminum pigments according to, e.g., claim 1, with at least one layer of silicon dioxide (SiO₂) significantly improves the ability of such pigments to resist corrosion, i.e., in comparison to pigments which do not possess such a priming coat. Evidence of this improved performance is provided in a paper by Albrecht, et al., "Sparkling With Optical Depth", published in *Powder Coatings Today* (2009). A copy of the subject paper is attached to this Amendment for the Examiner's consideration. Two of the paper's named authors (i.e., Messrs. Albrecht and Schreiber) are co-inventors of the present invention and application.

In reviewing the attached Albrecht et al. paper one must take into account the fact that a powder coating that is applied to a panel used as a facade on the outer surface of a building typically is subject to harsh environmental conditions. From Figures 7 and 8 of the subject paper it can be seen that silica-coated aluminum pigments have superior chemical resistance when compared to pigments (i.e., without such a coating) used in the prior art.

With regard to the Kaupp et al. reference mentioned above, the gist of the invention described therein is to provide passivated aluminum pigments that have been produced by a

physical vapor deposition (PVD) technique - i.e., in contrast to the pigments as now recited in, e.g., claim 1 as amended, which have been produced by milling. PVD aluminum pigments (i.e., as described by Kaupp et al.) are used only in liquid lacquers and paints and printing inks. They are also very expensive due to the complex process used in producing them. Such PVD-formed aluminum pigments are thus only used in applications wherein it is required for them to orient in a plane parallel to the substrate, thus leading to a superior optical effect due to the fact that the incident light is reflected in a directed manner.

The above-described orientation of PVD aluminum pigments is only possible in applications (such as those indicated above, i.e., liquid lacquers and paints and printing inks) which contain a liquid phase. In contrast to, e.g., paints and liquid lacquers, a powder coating composition (i.e., as recited in applicants' claim 1) does not contain any liquid. Therefore, it is not possible for the aluminum pigments according to, e.g., claim 1, to orient themselves in a plane parallel to the substrate. Thus, the optical properties obtained by applying PVD aluminum pigments in a paint or liquid lacquer can not be obtained when applying those pigments in a powder coating composition.

In view, therefore, of the fact that PVD aluminum pigments (i.e., as disclosed by Kaupp et al.) are several times more expensive than aluminum pigments (such as those recited in applicants' claim 1) produced with conventional milling technology, and further in view of the fact that the optical properties of PVD aluminum pigments mean that they can not be used in a powder coating composition (as recited in claim 1), PVD aluminum pigments - i.e., as described by the prior art Kaupp et al. reference, are not useful at all in a powder coating composition. Thus, since as indicated above the Kaupp et al. reference is directed to PVD aluminum pigments, applicants respectfully submit that one having an ordinary level of skill in the relevant field would not consider the disclosure of Kaupp et al when working in the field of milled pigments used in powder coatings. This, then, provides additional evidence in support of the non-obviousness of applicants' presently claimed pigments.

For the reasons given above, therefore, the Examiner is respectfully requested to reconsider and withdraw the §103 rejection as based on the combination of Camelon and Kaupp.

Further, in paragraph “(a)” bridging pp. 7-8 of the Office Action, claims 12-14, 16, 18-21, 39, 50 and 54 are rejected under 35 U.S.C. §103 over Camelion and further in view of Robinson et al. (WO 00/22053 with U.S. PATENT 7,244,780 taken as an equivalent), taken with evidence from ARALDITE® GT 6063 Product Specification. The rejection is respectfully traversed.

The ‘secondary’ references are apparently cited (as discussed in ¶¶29-33 of the Office Action) due to their disclosure with regard to various binders and anti-corrosion agents. However, notwithstanding whether and to what extent the disclosure contained within the subject references is appropriately characterized in the Office Action, applicants respectfully submit that neither the Robinson reference, nor the ARALDITE® GT 6063 Product Specification, provides any teaching or suggestion to provide the claimed metallic pigments, as recited in claim 1 from which the rejected claims all depend, with a silicon dioxide (SiO₂) barrier layer. Due to their dependence on claim 1, the rejected claims also include the above-described feature. Thus, despite whatever the secondary references contribute with regard to, e.g., binders and anti-corrosion agents, neither they by themselves, or when taken in combination with Camelion, would teach or suggest applicants’ metallic pigments as now claimed. No amount of disclosure regarding either or both of binders and/or anti-corrosion agents useful with the present metallic pigments should be relied upon as a teaching, or even a suggestion, to equip metallic pigments (as recited for example in claim 1) with a barrier layer of silicon dioxide, i.e., for the purpose of improving the corrosion resistance of the subject pigments (or for any other purpose).

For the reasons given above, therefore, the Examiner is respectfully requested to reconsider and withdraw the rejection of claims 18-21, 39 and 54 under 35 U.S.C. §103.

In ¶34 at p.9 of the Office Action, dependent claims 15 and 45 are rejected under 35 U.S.C. §103 over Camelion and further in view of U.S. PATENT 6,291,581 of Bayards et al. This rejection also is respectfully traversed.

The subject claims, like all of claims 2-54 pending in the Office Action, each depend from claim 1. Therefore these claims include all of the features recited in the independent claim. Claims 15 and 45 are thus deemed to be distinguishable over Camelion ‘347 for the reasons presented above. However, applicants recognize that the present rejection is based not on Camelion alone, but upon Camelion taken in combination with Bayards. As indicated, however,

at p. 10 of the Office Action the Bayards reference is cited due to its disclosure regarding binders for powder coating compositions. There is no indication that the secondary reference, in any way, supplies an important element not disclosed or even suggested in Camelon, i.e., the presence of at least one silicon dioxide barrier layer between the pigment and its enveloping outer coating. Thus, since neither reference viewed individually, or even both references taken in combination, supplies this important element of the invention, applicants respectfully submit that the subject matter of the claims in question (nos. 15 and 45) would not be obvious to one having an ordinary level of skill in the relevant art.

For the reasons presented above, therefore, the Examiner is respectfully requested to reconsider and withdraw the rejection under 35 U.S.C. 103 of claims 15 and 45.

Next, in ¶38 on p. 10 claims 23, 23 and 51 are rejected under 35 U.S.C. §103 over Camelon and further in view of U.S. PATENT 5,964,936 of Reisser et al. This ground of rejection is also respectfully traversed.

Applicants' position with regard to this ground of rejection is similar in nature to the arguments already presented above. That is, the rejected claims all depend from claim 1 and thus they include all of the features recited in the subject claim. As such, they are clearly distinguished over the primary Camelon reference since the subject reference neither discloses nor even suggests the provision of at least one intervening silicon dioxide barrier layer. It is apparent, moreover, from the discussion in Office Action paras. 39-41, that the Reisser et al. U.S. patent combined with Camelon does not supply the feature(s) of the invention lacking from the disclosure of Camelon. That is, Reisser et al. is cited due to its disclosure of oxidized aluminum flake pigments. There is no indication, however, in either the Office Action or the reference itself that Reisser et al. would supply any teaching or disclosure which would suggest to one having an ordinary level of skill in the relevant art to prime such pigments with an intervening layer of silicon dioxide, i.e., to protect the pigments against corrosion - or for any other reason.

Thus since neither Camelon or Reisser teach or suggest this important feature of the presently claimed metallic pigments, whether the references are taken individually or in combination, the subject claims are submitted to not be obvious over the cited combination of

references. The Examiner, therefore, is respectfully requested to reconsider and withdraw the rejection of claims 23, 24 and 51 under §103.

Claim 42 is, furthermore, rejected under 35 U.S.C. §103 in ¶42 on p. 11. According to the Office Action the subject claim would be “obvious” to one having an ordinary level of skill in the relevant field at the time the present invention was made over the Camelon reference taken in combination with U.S. Patent No. 5,319,001 to Morgan et al. The rejection is respectfully traversed by applicants.

In like manner to the arguments set forth above in response to the other rejections under 35 U.S.C. 103, the rejected claim depends from (amended) claim 1 and thus it includes all of the features recited in that claim. Thus claim 42 is neither taught nor suggested by Camelon. Furthermore, the combination of Camelon with Morgan et al. brings one no closer to applicants’ claimed pigment. That is, the Office Action makes it clear that the Morgan et al. reference is cited due to its disclosure regarding, *inter alia*, the use of a fluidized bed apparatus for coating and drying. There is no indication, either in the Office Action or in the reference itself, that the reference contains any disclosure which would teach or suggest to prime a metallic pigment, as recited for example in (amended) claim 1, i.e., with at least one barrier layer of SiO₂. Applicants respectfully submit, therefore, that claim 42 thus would not be obvious over the combination of Camelon and Morgan cited in the Office Action to reject the subject claim.

The Examiner is respectfully requested to reconsider and withdraw the rejection under 35 U.S.C. §103 of claim 42.

Double Patenting Rejections

In ¶47 on p. 12 of the Office Action, claims 1, 8, 9, 25 and 46-49 are rejected on the ground of non-statutory obviousness-type double patenting over claims 1, 3, 4, 7, 9, 11 and 12 of U.S. Patent No. 6,287,695 of Kaupp et al. in view of the Camelon et al. U.S. Patent No. 3,932,347. This rejection is respectfully traversed.

To briefly summarize the rejection, the Examiner is taking the position that the ‘695 Kaupp et al. patent claims passivation layer-coated aluminum-based metallic pigments but does not disclose coating such pigments with a polymeric binding agent. Further according to the

Office Action, "the passivation layer comprises at least one of phosphoric/phosphonic acids and derivatives thereof having 8-20 carbon atoms, metal oxide layers and crosslinked polymers, e.g., acrylates (clm. 7, 8, 11, 12)." The '347 Camelion patent is combined with Kaupp et al. due to the latter reference's disclosure of a powder coating composition comprising metal particles (used as a coloring agent) wherein the metal particles are encapsulated in a thermosettable binder, which may be a chemically cross-linkable polymer or copolymer.

The Kaupp et al. '695 patent, however, suffers from the same deficiency as the Kaupp et al. U.S. Published Application No. 2002/0168484 discussed above insofar as its disclosure relating to the passivating layer is concerned. That is, the subject reference does not teach or suggest that any metal oxide and/or metal hydroxide may prove useful in forming the passivation layer. Rather, the authors of the reference list a specific group of useful metals from which such metal oxide/metal hydroxide layers can be formed. The subject metals listed in the reference are as follows: B, Al, Sn, Ti, V, Cr, Mo, Zn and Ce (see, e.g., col. 3, lines 50-54 and claims 8 and 9). It is to be noted, however, that silicon is not included and, thus, silicon dioxide (SiO_2) is not one of the metal oxide layers disclosed by the reference.

Nor should this material (i.e., SiO_2) be considered as being suggested by the reference. The authors apparently made a conscious effort to exclude it from the list of metals they felt were useful in their invention. They might have, for example, indicated that the metals recited in col. 3 were listed as examples of materials that would work in the invention. They chose not to do so, however. Instead, they intentionally chose to recite that the passivating layer of their invention in the present context is at least one metal oxide and/or metal oxide layer formed from a specific (i.e., exclusive) group of metals (i.e., and only from the indicated group). This can hardly be said, then, to suggest the use of metals that are not included in the recited group. Applicants take the position, therefore, that those metals not included in the list provided in Kaupp do not form a part of the invention described in the subject reference and that Kaupp et al.'s failure to list the specific metal oxide chosen for use by the present applicants takes applicants' claimed barrier layer(s) outside the ambit of the disclosure contained in the subject reference since it can not be construed as even suggesting the inclusion of a SiO_2 barrier layer as presently recited in applicants' claims.

In addition, the Examiner's attention is respectfully directed to the arguments above in the discussion of the rejection under 35 U.S.C. §103 of applicants' claims 8-10, 25 and 46-49 with regard to the paper attached to this response authored by Albrecht et al. The remarks provided in the above-indicated portion of the response in regard to Kaupp et al. US 2002/0168484 A1 are equally applicable to Kaupp et al. U.S. PATENT 6,287,695. Thus the Albrecht et al. paper is believed to provide additional support for applicants' position that the present claims are non-obvious.

For the reasons given above, therefore, the Examiner is respectfully requested to reconsider and withdraw the double patenting rejection as based Kaupp '695 in view of Camelon.

Further to the above, in ¶52 on p. 13 the Office Action alleges that claims 1, 8, 9, 25 and 46-49 are directed to an invention not patentably distinct from that recited in claims 1, 3, 4, 7, 8, 11 and 12 of the Kaupp '695 patent, i.e., based on the discussion set forth in ¶¶ 47-51 of the Action.

According to para. 53 of the Office Action, the commonly assigned '695 patent would form the basis for a rejection of the noted claims under 35 U.S.C. 103(a) if the commonly assigned case qualifies as prior art under 35 U.S.C. 102(e), (f) or (g) and the conflicting inventions were not commonly owned at the time the invention in this application was made. In order that the Examiner may resolve this issue (as discussed in ¶53) applicants assert that the conflicting inventions were commonly owned at the time the invention in this application was made. According to ¶54 of the Action, therefore, such an assertion of common ownership precludes a rejection of the above-indicated claims under 35 U.S.C. 103 based upon the commonly assigned case as a reference under 35 U.S.C. 102 (f) or (g).

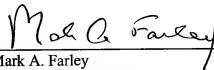
Notwithstanding any of the matters discussed above, however, applicants respectfully submit that the claims as pending in the present application are, in fact, patentably distinct from those which have issued in the Kaupp '695 patent in that they are believed to clearly display an Inventive Step thereover. Applicants claims as pending in this application are specifically directed to a metallic pigment that is primed with a SiO₂ layer positioned between the pigment surface and the outer enveloping layer. This priming layer is neither taught nor even suggested

by the Kaupp et al. '695 patent for the reasons presented above, whether the subject patent is taken alone, or in combination with the Camelon '347 reference. Applicants respectfully submit, therefore, that there is no basis for rejecting the presently pending claims, under either §§102 or 103 over the subject Kaupp et al. patent.

Thus, with regard to the rejection set forth in ¶55 of the Office Action, i.e., wherein applicants' claims 1, 8, 9, 25 and 46-49 are rejected under 35 U.S.C. 103 over Kaupp '696 in view of Camelon '347, the Examiner's attention is respectfully directed to the remarks set forth above, which are expressly incorporated by reference in to this discussion regarding the subject rejection. For the reasons presented, therefore, the Examiner is also respectfully requested to reconsider and withdraw the subject rejection under §103.

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Respectfully submitted,



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Sparkling with optical depth

Binder-encapsulated metallic-effect pigments offer a new look and improved properties

Alexander Albrecht,
Ulrich-Andreas Hirth
and Burkhard Schreiber

New types of binder-coated aluminium pigments for metallic powder coatings exhibit innovative optical effects. Properties such as recoverability, abrasion resistance and corrosion resistance have been improved in comparison with established high-performance aluminium pigments.

Powder coating technology has been one of the most interesting and fastest-growing coating technologies for several decades now due to its ecological and economic advantages. Powder coatings are environmentally friendly because they are solvent-free – and hence emission-free. The recoverability of the overspray and the high application efficiency guarantee optimum utilisation of the materials employed. Coating layers of sufficient thickness and optical appeal can be applied to the substrate in just one pass. The coatings exhibit good surface qualities and high mechanical and chemical resistance. Thanks to these favourable properties, powder coatings have found their way into diverse applications and are used widely, for example, in the coating of household appliances, furniture and tools. They also serve well in outdoor applications, such as façade coating or in the automotive sector.

METALLIC PIGMENTS WERE PREVIOUSLY NOT OPTIMALLY WETTED IN POWDER COATINGS

Thanks to the nearly universal design possibilities and high-value appearance of metallic pigmented coating surfaces, silver metallic effects have attracted the interest of users and designers for years. Therefore aluminium pigment powders are supplied for powder coating applications which are particularly suitable for electrostatic application processes. This applies to both leafing pigments which float to the coating surface during the melting phase and non-leafing pigments which instead distribute themselves within the coating layer [1–3]. Due to their superior weather and abrasion resistance, non-leafing pigments are primarily employed in powder coating applications. Today, special aluminium pigments are available using a variety of different pigment coating technologies depending on the desired aluminium pigment properties. The best resistances are shown by aluminium pigments encapsulated in a nano-scale SiO₂-layer [4].

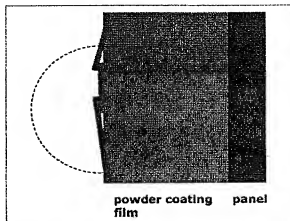


Figure 1: Aluminium pigments with established pigment coating concept frequently not optimally wetted in cured powder coating

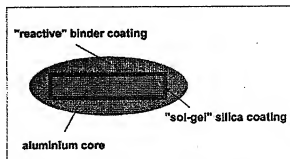


Figure 2: Schematic cross section of an aluminium pigment with the new pigment coating concept

Despite the progress in pigment coating and encapsulation technologies made in recent times, there is still room for improvement (Figure 1):

- Platelet-shaped metallic-effect pigments and spherical powder coating particles can separate during the application and recovery of (dry-blend) metallic powder coatings. This can result in undesired shifts of colour shade (bonding can provide some help here).

- Platelet-shaped metallic-effect pigments are often not optimally wetted by the powder coating. In particular, the pigments can protrude from the surface of the powder coating layer.
- Pigments near the surface can be removed by abrasion due to the fact that they are often inadequately surrounded by the coating layer.
- Platelet-shaped metallic-effect pigments are often inadequately embedded in the coating film. At the coating surface they are completely exposed to the weather and can be decomposed by oxidising chemicals. The metallic effect can get lost. Even highly stable aluminium pigments may suffer damage over time in particularly harsh conditions.

NEW PIGMENT COATING CONCEPT: BINDER-ENCAPSULATED PIGMENTS ACHIEVE STRONG CROSS-LINKING

The aluminium pigments that have now been developed no longer exhibit these disadvantages. The pigments in question are aluminium pigments in which each individual metallic pigment core is completely surrounded by reactive binder components that are typical to powder coatings (Figure 2). The binder components in the form of resin and curing agents are applied to the pigments in an optimum (stoichiometric) ratio for the cross-linking reaction. The cross-linking reaction does not occur during manufacturing due to the gentleness of the manufacturing process. Later (in the powder coating application process) the binder components do react with the powder coating matrix and cross-link the metallic-effect pigments firmly in the powder coating film (Figure 3). Theoretically, all commonly used powder coating systems are conceivable for aluminium pigment refining. In practice, however, not every system has proven to be suitable. Tests with various polyester systems have shown that components combining resins and curing agents made from hydroxy-functional polyesters and polyisocyanate adducts yield optimum results. Particularly favourable were pigment-to-binder ratios of 1:1.

Application tests in epoxy-polyester, polyester-PT910, polyester-prime, polyurethane and hydroxy-functional acrylate systems demonstrated broad compatibility.

NEW ALUMINIUM PIGMENT DELIVERS 3D-EFFECT

Extraordinary effects differing in important ways from established silver metallic effects in powder coatings were found in all applications with the new aluminium pigment. In powder clear coats containing the new aluminium pigments three-dimensional metallic effects combined with unique optical depth can be obtained with just one powder coating layer. In particularly bright lighting conditions, for instance in direct sunlight, an extraordinary sparkle effect can be provided (which could previously only be achieved in wet coating processes). Moreover, even though it is a single-layer coating, there appears to be a clear-coat layer on top of this application – even to the trained eye. Figure 4 shows the astounding effect.

IMPROVED RECOVERY AND STORAGE STABILITY

In order to compare the new aluminium pigment with a known high-performance aluminium pigment, a pigment quality with an average particle size of 35 µm was used in both cases. APU powder clear coat was used as basic powder coating. To achieve optimum

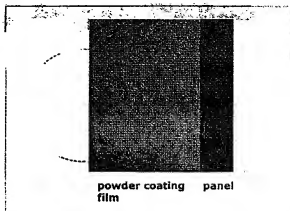


Figure 3: Aluminium pigments with the new pigment coating concept are firmly incorporated into the cured powder coating film



Figure 4: Effect shown by the new aluminium pigment on a powder-coated bottle body

coverage with a full silver shade, a pigmentation level of 5 % was selected for the known established high-performance aluminium pigment and a level of 10 % for the new aluminium pigment.

The recoverability (powder recycling stability) was tested on a black polyester powder coating with pigmentation levels of 1 % (established high-performance aluminium pigment) and 3 % (new aluminium pigment). After the respective powder coating was applied to a panel as a control sample, the powder coating was passed through a cyclone and recovered three times in a row. The recovered powder was then applied again to a panel. Determination of the dE value (differential value between sample after cycloning and control panel) yielded colour shade differences of no more than one unit for all measured angles for the new aluminium pigment (15°, 25°, 45°, 75° and 110°). With the established high-performance aluminium pigment the differences were much greater; at an an-

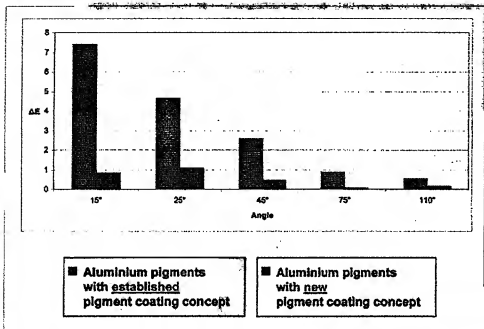


Figure 5: Colour shade differences after three recovery cycles

gle of 15° a value of more than 7 units was found (Figure 5). The measurement results document the improved recoverability of a metallic pigmented powder coating (dry blend) when the new aluminium pigment is used.

The storage stability of the new aluminium pigment is very good. Investigations of the resistance to caking according to DIN 55990 showed that even after 28 days of storage at 40 °C no caking occurs.

HIGH ABRASION RESISTANCE

For determination of the abrasion resistance sample panels of the new aluminium pigment and the established high-performance pigment were subjected to a cleaning test. For this a standardised cleaning cloth (abrasive surface area: 36 cm²) was dipped in a cleaning fluid (Ambruch 2 plastic intensive cleaner) and moved back and forth 40 times (40 double strokes) over the coating surface under a load of 450 g. The known high-performance aluminium pigment (Figure 6a) leaves noticeable silver-grey marks on the cloth. Figure 6b shows that through the optimum embedding of the new aluminium pigments in the powder coating nearly no abraded aluminium material can be found on the cleaning cloth. The result documents great progress in the ability to clean single-coat metallic-effect surfaces.

EFFECT AND COLOUR REMAIN CONSTANT IN MORTAR TEST

Various methods are used in practice to determine the weather and chemical resistance of metallic pigmented powder coatings. For aluminium pigments encapsulated by SiO₂ through a sol-gel process, outstanding chemical resistance properties could be demonstrated in test climates such as those of the condensation water test and the Kesternich test [4] (where no changes could be detected visually after testing).

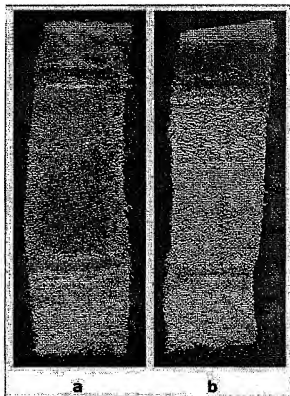


Figure 6: Cleaning cloths after abrasion test with 40 double strokes using cleaning fluid
a) Aluminium pigments with established pigment coating concept
b) Aluminium pigments with new pigment coating concept

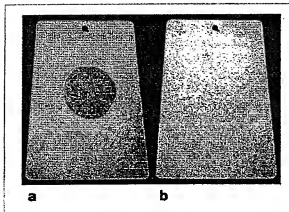


Figure 7: Powder-coated sample panels after testing for mortar resistance:

- a) Aluminium pigments with established pigment coating concept
- b) Aluminium pigments with new pigment coating concept

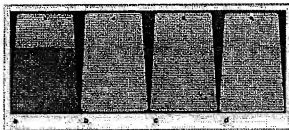


Figure 8: Powder-coated sample panels after testing for chemical resistance:

- a) Aluminium pigments with established pigment coating concept: NaOH-treatment
- b) Aluminium pigments with new pigment coating concept: NaOH-treatment
- c) Aluminium pigments with established pigment coating concept: HCl-treatment
- d) Aluminium pigments with new pigment coating concept: HCl-treatment

Even more stringent requirements for chemical resistance are now met by the new aluminium pigments. For façade applications, the mortar test of GSB International is of particular importance. Investigations on the new aluminium pigments and the established high-performance pigment on sample panels were carried out according to the testing guidelines of GSB International [5]. For this purpose, mortar made of building lime, sand and water is prepared. The cooled mortar mass is applied while still wet to the respective sample panel as a patch with a diameter of approx. 5 cm. The panel is immediately exposed to a relative humidity of 95 % to 100 % and a temperature of 40 °C for a 24-hour period. After the test period the mortar patch is removed and the panel cleaned and evaluated. The following ratings are used to describe the change in the effect in the affected area in accordance with the testing guidelines of GSB International: 1 (no difference between

LIFELINE

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tested surface and untested surface), 2 (hardly visible colour and effect changes), 3 (visible colour and effect changes), 4 (clearly visible colour and effect changes) and 5 (marked changes in colour – complete loss of effect). The panel with the known high-performance aluminium pigment shows a clearly affected surface in the affected area and receives a rating of 4 (Figure 7a). In contrast, the panel with the new aluminium pigment allows no difference between the affected and unaffected areas to be detected and receives the rating of 1 (Figure 7b).

CHEMICAL RESISTANCE

In order for the chemical resistance to be investigated panels containing the new aluminium pigment and the known high-performance pigment were tested with a 10 % sodium hydroxide solution and 10 % hydrochloric acid after being stored for 24 hours. In the NaOH-test, one of each of the test panels is dipped halfway into a sodium hydroxide bath for three hours.

For the HCl test 4 ml of hydrochloric acid is applied to the surface of each panel and left on the surface for three hours. After the residence time, the panels are carefully rinsed under running water. The affected area is compared with the unaffected area and rated according to the following grades: 1 (no difference between tested surface and untested surface), 2 (hardly visible greying), 3 (visible greying), 4 (considerable greying) and 5 (complete loss of effect). In the test with sodium hydroxide, the panel with the known high-performance aluminium pigment shows considerable greying and is rated grade 4 (Figure 8a). The panel with the new aluminium pigment, in comparison, shows hardly visible greying and is rated grade 2 (Figure 8b). The test with hydrochloric acid shows similar results: the panel with the established high-performance aluminium pigment (Figure 8c) is hardly greied (grade 2) and the panel with the new aluminium pigment (Figure 8d) shows no difference at all between the affected and unaffected areas (grade 1). The results of the mortar and chemical resistance tests are summarised in Figure 9.

POWDER COATINGS TODAY

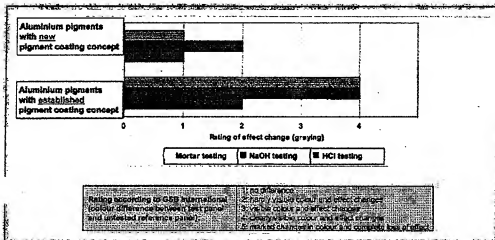


Figure 9: Measurement results from mortar and chemical resistance tests

WET-COATING-LIKE EFFECTS IN POWDER COATING SYSTEMS

The further refining of aluminium pigments through encapsulation with thermally curable binders produces a variety of advantages in comparison with known aluminium pigments for powder coating applications. For example, the improved recoverability increases the value-in-use. Improvements in mortar and chemical resistance can open up new application areas for metallic powder coatings, especially in outdoor applications. Through optimum embedding of the new aluminium pigments in the powder coating matrix, results can be achieved that are otherwise only achievable in wet coatings. For one thing, sparkle effects can be obtained that exhibit an optical depth previously impossible in powder coatings. Moreover, extraordinary abrasion resistance and optimized cleanability results from optimum incorporation of the new aluminium pigments into the powder coating film.

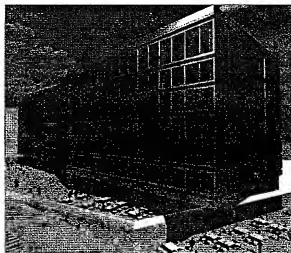


Figure 10: Rendering picture of a building in the Hamburg Hafen City with powder coated facade elements containing the new aluminium (by courtesy of architects Schenk + Walbinger)

Architects and designers already have discovered the colouristic potential of the new aluminium pigments for the building industry. Figure 10 shows a rendering picture of a representative building object in the "Hamburg Hafen City" (that will be finished end of 2008) with powder coated facade elements containing the new aluminium pigment.

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AT A GLANCE

- In powder coating applications, a binder-encapsulated aluminium pigment opens up new effect potential that previously could only be obtained in wet coating.
- The binder-encapsulated aluminium pigment improves the recoverability of metallic powder coating.
- The abrasion resistance and therefore the cleanability of single-layer metallic powder coatings are significantly increased.
- Encapsulation of metallic pigments with a binder significantly increases their weathering and chemical stability.